

MODIFIED WEATHERABLE POLYESTER MOLDING COMPOSITION

FIELD OF THE INVENTION

The field is directed to modified thermoplastic resin compositions, and, more particularly, to weatherable and impact modified compositions containing a blend of a polyester resin and a polycarbonate resin.

BACKGROUND OF THE INVENTION

5 Moldable thermoplastic polyester crystalline resin blends offer a high degree of surface hardness, solvent resistance and abrasion resistance, high gloss, and low surface friction. However, loss of impact strength when subjected to ultra violet radiation may limit the usefulness of polyester crystalline resin blends for outdoor applications where molded articles made from the polyester will be exposed to sun and hot wet conditions.

10 Often a rubbery modifier is added to polyesters to improve impact strength. For example, improved impact strength is obtained by melt compounding polybutylene terephthalate with ethylene homo- and copolymers functionalized with either acid or ester moieties as taught in U.S. Pat. Nos. 3,405,198; 3,769,260; 4,327,764; and 4,364,280. Polyblends of polybutylene terephthalate with a styrene-
15 alpha-olefin-styrene triblock are taught in U.S. Pat. No. 4,119,607. U.S. Pat. No. 4,172,859 teaches impact modification of polybutylene terephthalate with random ethylene-acrylate copolymers and EPDM rubbers grafted with a monomeric ester or acid functionality.

20 Although articles molded from impact-modified polyester resin/polycarbonate resin blends typically provide good impact performance, the weatherability of the such articles may be deficient in some applications where it is desired to retain the impact resistance after long term UV exposure. Hence, it is desirable to provide a

molding composition having a combination of flame resistance, impact resistance with enhanced weatherability.

US Patent No. 4,161,469 describes a polymer blend comprising a polyalkyl terephthalate resin and organosiloxane-polycarbonate block copolymer having improved impact and heat distortion properties. US Patent No 4,794,141 describes polysiloxane/polycarbonate block copolymers, elastomeric polymers, and polyalkylene terephthalates. The elastomeric polymer is described as a hydrogenated block copolymer of a vinyl aromatic monomer and a conjugated diene. US Patent No. 5,380,795 describes a polymer mixture comprising an aromatic polycarbonate, a styrene-containing copolymer and/or graft polymer, and a polysiloxane-polycarbonate block copolymer, and articles formed therefrom. However, these patents do not describe flame-retarded blend and do not address question of weatherability of the blends.

US Patent No. 4,155,898 describes a polymer blend comprising a polyalkylene terephthalate, an organopolysiloxane-polycarbonate block copolymer, and a halogenated copolycarbonate having impact, heat distortion and flame retardant properties.

US Patent No. 5,981,661 describes a flame retarded molding compositions with enhanced weatherable properties, which comprise a polyester and polycarbonate blend with organopolysiloxane-polycarbonate block copolymer and a glycidyl ester impact modifier. However, high amount of glycidyl impact modifier could cause undesirable viscosity increase through the reaction between glycidyl groups in the impact modifier and carboxyl groups in polyesters. In addition, glycidyl impact modifier is less effective impact modifiers than core-shell type rubbers. Accordingly, there is a need for enhancing the impact and processibility, as well as the retention of impact and color upon long term UV exposure. The present invention demonstrates good weatherable polyester crystalline resin blends with flame retardant for outdoors application.

SUMMARY OF THE INVENTION

According to an embodiment, a flame-retarded resin molding compositions with weatherable properties comprise a polyester and polycarbonate blend modified with an organopolysiloxane-polycarbonate and an acrylic impact modifier for enhancing weatherability.

According to other embodiments, additional ingredients may include a flame retarding amount of a halogenated flame retardant, a mineral filler, and other ingredients such as quenchers, flame retardant synergist, and anti-drip additives.

According to an embodiment, a thermoplastic resin comprises polycarbonate, an alkylene aryl polyester, an organopolysiloxane-polycarbonate, and a core-shell impact modifier for enhancing heat resistance having a shell derived from an alkylacrylate and a rubbery acrylate core derived from an acrylate having 4 to 12 carbon atoms and the core may have silicone copolymers.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Polycarbonate Resin Component

Aromatic polycarbonate resins suitable for use in the present invention, methods of making polycarbonate resins and the use of polycarbonate resins in thermoplastic molding compounds are well known in the art, see, generally, U.S. Patent Nos. 3,169,121, 4,487,896 and 5,411,999, the respective disclosures of which are each incorporated herein by reference.

Aromatic polycarbonate resins are, in general, prepared by reacting a dihydric phenol, e.g., 2, 2-bis(4-hydroxyphenyl) propane ("bisphenol A"), 2,2-bis(3,5-dimethyl-4-hydroxyphenyl)propane, bis(2-hydroxyphenyl) methane, 2,6-dihydroxy naphthalene, hydroquinone, 2,4'-dihydroxyphenyl sulfone and 4, 4'-dihydroxy-3, 3-dichlorophenyl ether, with a carbonate precursor, e.g., carbonyl bromide and carbonyl chloride, a halogen formate, a bishaloformate of a dihydric phenol or a carbonate

ester, e.g., diphenyl carbonate, dichlorophenyl carbonate, dinaphthyl carbonate, phenyl tolyl carbonate and ditolyl carbonate.

In a preferred embodiment, the aromatic polycarbonate resin comprises one or more resins selected from linear aromatic polycarbonate resins, branched aromatic polycarbonate resins and poly(ester-carbonate) resins.

Suitable linear aromatic polycarbonates resins include, e.g., bisphenol A polycarbonate resin.

Suitable branched aromatic polycarbonates are made, e.g., by reacting a polyfunctional aromatic compound, e.g., trimellitic anhydride, trimellitic acid, trimesic acid, trihydroxy phenyl ethane or trimellityl trichloride, with a dihydric phenol and a carbonate precursor to form a branching polymer.

Suitable poly(ester-carbonate) copolymers are made, e.g., by reacting a difunctional carboxylic acid, terephthalic acid, isophthalic acid, 2,6-naphthalic acid, or mixtures of acids, or a derivative of a difunctional carboxylic acid, e.g., an acid chloride, with a dihydric phenol and a carbonate precursor.

In a preferred embodiment, the polycarbonate resin has an intrinsic viscosity of about 0.3 to about 1.5 deciliters per gram in methylene chloride at 25°C.

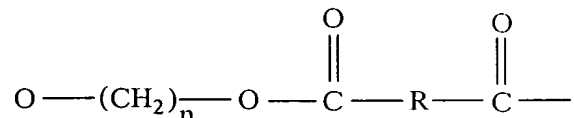
In a preferred embodiment, the polycarbonate resin is a linear polycarbonate resin that is derived from bisphenol A and phosgene. In an alternative preferred embodiment, the polycarbonate resin is a blend of two or more polycarbonate resins.

Suitable aromatic polycarbonate resins are commercially available, e.g., LEXAN™ bisphenol A-type polycarbonate resins from General Electric Company.

Polyester

The term alkylene aryl polyester refers to crystalline thermoplastic polyesters such as polyesters derived from an aliphatic or cycloaliphatic diols, or mixtures

thereof, containing from 2 to about 10 carbon atoms and at least one aromatic dicarboxylic acid. Preferred polyesters are derived from an aliphatic diol and an aromatic dicarboxylic acid having repeating units of the following general formula:



5 wherein n is an integer of from 2 to 6. R is a C₆-C₂₀ aryl radical comprising a decarboxylated residue derived from an aromatic dicarboxylic acid.

Examples of aromatic dicarboxylic acids represented by the decarboxylated residue R are isophthalic or terephthalic acid, 1,2-di(p-carboxyphenyl)ethane, 4,4'-dicarboxydiphenyl ether, 4,4' bisbenzoic acid and mixtures thereof. All of these acids
10 contain at least one aromatic nucleus. Acids containing fused rings can also be present, such as in 1,4- 1,5- or 2,6- naphthalenedicarboxylic acids. The preferred dicarboxylic acids are terephthalic acid, isophthalic acid, naphthalene dicarboxylic acid or mixtures thereof.

The most preferred polyesters are poly(ethylene terephthalate) ("PET"), and
15 poly(1,4-butylene terephthalate), ("PBT"), poly(ethylene naphthanoate) ("PEN"), poly(butylene naphthanoate), ("PBN") poly(propylene terephthalate) ("PPT") and poly(cyclohexane dimethanol terephthalate), (PCT).

Also contemplated herein are the above polyesters with minor amounts, e.g., from about 0.5 to about 5 percent by weight, of units derived from aliphatic acid
20 and/or aliphatic polyols to form copolyesters. The aliphatic polyols include glycols, such as poly(ethylene glycol). Such polyesters can be made following the teachings of, for example, U.S. Pat. Nos. 2,465,319 and 3,047,539.

The preferred poly(1,4-butylene terephthalate) resin used in this invention is one obtained by polymerizing a glycol component at least 70 mol %, preferably at
25 least 80 mol %, of which consists of tetramethylene glycol and an acid component at

least 70 mol %, preferably at least 80 mol %, of which consists of terephthalic acid, or polyester-forming derivatives therefore.

The polyesters used herein have an intrinsic viscosity of from about 0.4 to about 2.0 dl/g as measured in a 60:40 phenol/tetrachloroethane mixture or similar solvent at 23°-30° C. VALOX 315 polyester is particularly suitable for this invention
5 having an intrinsic viscosity of 1.1 to 1.4 dl/g.

A mixture of polyester resins with differing viscosities may be used to make a blend mixture to allow for better control of the viscosity of the final formulation.

Blends of polyesters may also be employed in the composition. As indicated
10 earlier, preferred polyester blends are made from poly(ethylene terephthalate) and poly(1,4-butylene terephthalate).

Acrylic Impact Modifier

The composition comprises an impact modifier, preferably a core-shell polymers built up from a rubber-like core on which one or more shells have been
15 grafted. Typical core material consists substantially of an acrylate rubber. Preferable the core is an acrylate rubber of derived from a C4 to C12 acrylate. Typically, one or more shells are grafted on the core. Usually these shells are built up for the greater part from a vinyl aromatic compound and/or a vinyl cyanide and/or an alkyl(meth)acrylate and/or (meth)acrylic acid. Preferable the shell is derived from an
20 alkyl(meth)acrylate, more preferable a methyl(meth)acrylate. The core and/or the shell(s) often comprise multi-functional compounds that may act as a cross-linking agent and/or as a grafting agent. These polymers are usually prepared in several stages. The preparation of core-shell polymers and their use as impact modifiers in combination with polycarbonate are described in U.S. Patent Nos. 3,864,428 and
25 4,264,487. Especially preferred grafted polymers are the core-shell polymers available from Rohm & Haas under the trade name PARALOID®, including, for example, PARALOID® EXL3330 and EXL2300.

In another aspect of the invention the acrylic core shell rubber comprises a multi-phase composite interpolymer comprising about 25 to 95 weight percent of a first acrylic elastomeric phase polymerized from a monomer system comprising about 75 to 99.8% by weight C_1 to C_{14} alkyl acrylate, 0.1 to 5% by weight cross linking member, 0.1 to 5% by weight graft linking monomer, said cross linking monomer being a polyethylenically unsaturated monomer having a plurality of addition polymerizable reactive groups and about 75 to 5 weight percent of a final, rigid thermoplastic acrylic or methacrylic phase polymerized in the presence of said elastomer.

Preferred impact modifiers include core-shell impact modifiers, such as those having a core of poly(butyl acrylate) and a shell of poly(methyl methacrylate).

In other embodiments suitable impact modifiers comprise those that are core-shell type impact modifiers including shell comprising poly(methyl methacrylate) and core comprising a silicone rubber and at least one poly(alkylacrylate). In a particular embodiment a suitable impact modifier is core-shell type impact modifiers including shell comprising poly(methyl methacrylate) and core comprising a silicone rubber and at least one poly(butylacrylate). One type of suitable core-shell impact modifier can be prepared in accordance with the method described in US Patent No. 5,132,359. In some embodiments suitable impact modifiers include those sold under the trade name Metablend by Mitsubishi Rayon Co. Ltd.

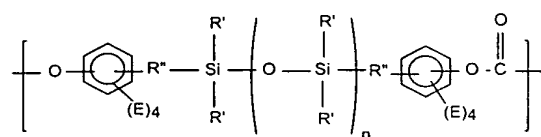
A useful amount of impact modifier is about 1 to about 30 weight percent, preferably about 5 to about 15 weight percent, more preferably about 6 to about 12 weight percent, wherein the weight percentages are based on the entire weight of the composition.

Core shell acrylic rubbers can be of various particle sizes. The preferred range is from 300-800 nm, however larger particles, or mixtures of small and large particles, may also be used. In some instances, especially where good appearance is required acrylic rubber with a particle size of 350-450 nm may be preferred. In other

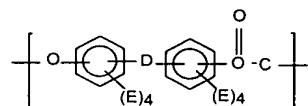
applications where higher impact is desired acrylic rubber particle sizes of 450-550 nm or 650-750 nm may be employed.

The Siloxane-Copolycarbonate Block Copolymer

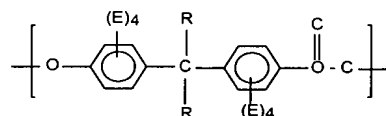
Preferred polysiloxane-polycarbonate block copolymers are set forth in
 5 copending application Serial Number 08/062,485 entitled Polymer blends of
 Polycarbonate-Polysiloxane block Copolymers with Polycarbonate and
 Polyester carbonate Copolymers by Hoover (Our Case 8CL-7015). The blend
 comprises a polysiloxane from recurring polysiloxane blocks of the formula:



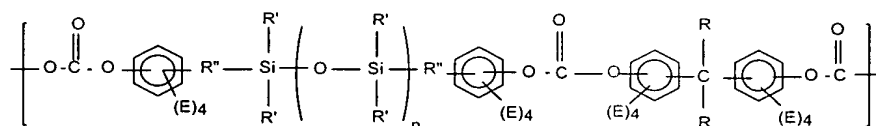
10 The polycarbonate-block comprises units of the formula:



with the preferred polycarbonate-block comprises units of the formula:



The resulting organopolysiloxane-polycarbonate block copolymer includes
 15 organopolysiloxane-polycarbonate blocks having repeating units of the general
 formula:

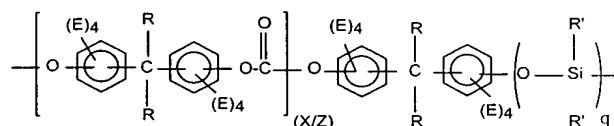


In the above formulae, R' is a member selected from the class of monovalent hydrocarbon radicals, halogenated monovalent hydrocarbon radicals and cyanoalkyl radicals; E is a member independently selected from the class of hydrogen, lower alkyl, alkoxy radicals, aryl, and alkylaryl, halogen radicals and mixtures thereof, preferably hydrogen or alkoxy and when alkoxy, preferably methoxy; R" is a divalent hydrocarbon radical, preferably an alkylene radical of from 1 to 6 carbon atoms with C₃ being most preferred, and n is from about 10 to about 120, preferably from about 40 to about 60.

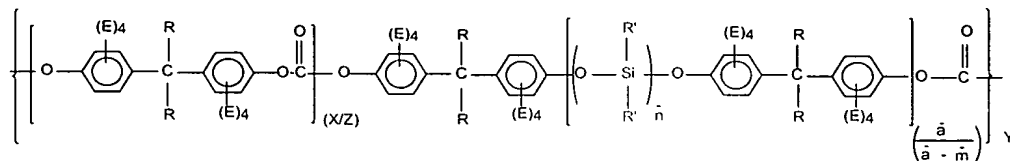
A is a divalent hydrocarbon radical containing from 1-15 carbon atoms; -S-, -SO-, -S(O)₂-, -O-. Preferably D is a divalent hydrocarbon radical. In the case where A is -C(R)₂-, R is a member selected from the class of hydrogen, cycloaliphatic, aryl, monovalent hydrocarbon radicals, aryl or alkylaryl, preferably R is alkyl, preferably C1-C6 alkyl, and more preferably methyl.

Preferred polysiloxane-polycarbonate block copolymers are set forth in copending application Serial Number 08/062,485, comprise from about 1 to about 50 percent by weight of siloxane. Pages 2-14 of the above mentioned application are incorporated into the present specification by reference. These pages relate to the preferred polycarbonate-polysiloxane blocks of utilized in the present invention. Additional preferred embodiments are set forth in S.N. 08/668,445 to Hoover et al entitled Terpolymer Having Aromatic Polyester, Polysiloxane and Polycarbonate Segments, (Our Case 8CL-7001) which pages 3-14 is incorporated into the present specification by reference.

Other illustrative organopolysiloxane block copolymers are set forth in U.S. patent 4,161,498 to Bopp which describes polysiloxane blocks of the following general formulae:



A organopolysiloxane-polycarbonate block copolymer of Bopp is represented by the following formula comprising organopolysiloxane-polycarbonate blocks having repeating units of the general formula:



5 where X is an integer equal to 1 to 1000, inclusive, preferably 2 to 100, Z is equal to 1, n is a number average equal to 1 to 100, inclusive, preferably 5 to 40, a is a number average equal to 1.1 to 100, m is equal to 1, and Z is an integer equal to 1 to 1000, inclusive, preferably 5 to 12. E, R, and R' being as defined hereinafter.

10 Included within the radicals represented by R aryl radicals and halogenated aryl radicals such as phenyl, chlorophenyl, xylyl, tolyl, etc.; aralkyl radicals such as phenylethyl, benzyl, etc.; aliphatic, haloaliphatic and cycloaliphatic radicals such as alkyl, cycloalkyl, haloalkyl including methyl, ethyl propyl, chlorobutyl, cyclohexyl, etc.; R can be all the same radical or any two or more of the aforementioned radicals, while R is preferably methyl, R' includes all radicals included by R above except
15 hydrogen, where R' also can be all the same radical or any two or more of the aforementioned R radicals except hydrogen and R' is preferably methyl. R' also includes, in addition to all the radicals included by R, except hydrogen, cyanoalkyl radicals such as cyanoethyl, cyanobutyl, etc. radicals. Radicals that are included within the definition of E are hydrogen, methyl, ethyl, propyl, chloro, bromo, etc. and
20 combinations thereof, and E is preferably hydrogen.

The organopolysiloxane-polycarbonate block copolymers can be made by any technique known to those skilled in the art including the techniques described by Merritt, Merritt, Jr., et al., and Vaughn Jr. in the U.S. patents referenced in the description of the prior art hereinbefore.

Accordingly, all of the procedures described in the aforesaid patents relating to methods for the preparation of the organopolysiloxane-polycarbonate block copolymers are incorporated herein in their entirety by reference.

Illustratively presently preferred organopolysiloxane-polycarbonate block copolymers contain repeating units of above Formula, set out herein before wherein X, Y, Z, a, n and m are as defined hereafter: Resin Type "A"; X equals about 7; Y equals about 8 to 10; Z equals about 1; a equals about 2; n equals about 10; m equals about 1. Resin Type "B"; X equals about 10; Y equals about 8 to 10; Z equals about 1; a equals about 2; n equals about 20; m equals about 1. Resin Type "C"; X equals about 5; Y equals about 8 to 10; Z equals about 1; a equals about 2; n equals about 20; m equals about 1.

Flame Retardant

Flame-retardant additives are desirably present in an amount at least sufficient to reduce the flammability of the polyester resin, preferably to a UL94 V-0 rating. The amount will vary with the nature of the resin and with the efficiency of the additive. In general, however, the amount of additive will be from 2 to 30 percent by weight based on the weight of resin. A preferred range will be from about 8 to 20 percent.

Typically halogenated aromatic flame-retardants include tetrabromobisphenol A polycarbonate oligomer, polybromophenyl ether, brominated polystyrene, brominated BPA polyepoxide, brominated imides, brominated polycarbonate, poly(haloaryl acrylate), poly(haloaryl methacrylate), or mixtures thereof.

Examples of other suitable flame retardants are brominated polystyrenes such as polydibromostyrene and polytribromostyrene, decabromobiphenyl ethane, tetrabromobiphenyl, brominated alpha, omega -alkylene-bis-phthalimides, e.g. N,N'-ethylene-bis-tetrabromophthalimide, oligomeric brominated carbonates, especially carbonates derived from tetrabromobisphenol A, which, if desired, are end-capped

with phenoxy radicals, or with brominated phenoxy radicals, or brominated epoxy resins.

The flame-retardants are typically used with a synergist, particularly inorganic antimony compounds. Such compounds are widely available or can be made in known ways. Typical, inorganic synergist compounds include Sb_2O_3 , SbS_3 , sodium antimonite and the like. Especially preferred is antimony trioxide (Sb_2O_3). Synergists, such as antimony oxides, are typically used at about 0.5 to 15 by weight based on the weight percent of resin in the final composition.

Fillers

Additionally, it may be desired to employ inorganic fillers to the thermoplastic resin provided the favorable properties are not deleteriously affected. Typical inorganic fillers include: alumina, amorphous silica, anhydrous aluminosilicates, mica, wollastonite, clays, talc, metal oxides such as titanium dioxide, zinc sulfide, ground quartz, and the like. Low levels (0.1-10.0 wt. %) of very small particle size (largest particles less than 10 microns in diameter) are preferred.

Fiber Additives

The polyester resins of the invention may be further blended with reinforcements, fillers and colorants.

Reinforcing fiber and fillers may comprise from about 5 to about 50 weight percent of the composition, preferably from about 10 to about 35 weight percent based on the total weight of the composition. The preferred reinforcing fibers are glass, ceramic and carbon and are generally well known in the art, as are their methods of manufacture.

In one embodiment, glass is preferred, especially glass that is relatively soda free. Fibrous glass filaments comprised of lime-alumino-borosilicate glass, which is also known as "E" glass are often especially preferred. Glass fiber is added to the

composition to greatly increase the flexural modulus and strength, albeit making the product more brittle. The glass filaments can be made by standard processes, e.g., by steam or air blowing, flame blowing and mechanical pulling. The preferred filaments for plastic reinforcement are made by mechanical pulling. For achieving optimal mechanical properties fiber diameter between 6-20 microns are required with a diameter of from 10-15 microns being preferred. In preparing the molding compositions it is convenient to use the fiber in the form of chopped strands of from about 1/8" to about 1/2" long although roving may also be used. In articles molded from the compositions, the fiber length is typically shorter presumably due to fiber fragmentation during compounding of the composition. The fibers may be treated with a variety of coupling agents to improve adhesion to the resin matrix. Preferred coupling agents include; amino, epoxy, amide or mercapto functionalized silanes. Organo metallic coupling agents, for example, titanium or zirconium based organo metallic compounds, may also be used.

Other preferred sizing-coated glass fibers are commercially available from Owens Corning Fiberglass as, for example, OCF K filament glass fiber 183F

Other fillers and reinforcing agents may be used in alone or in combination with reinforcing fibers. These include but are not limited to: carbon fibrils, mica, talc, barite, calcium carbonate, wollastonite, milled glass, flaked glass, ground quartz, silica, zeolites, and solid or hollow glass beads or spheres.

The glass fibers may be blended first with the aromatic polyester and then fed to an extruder and the extrudate cut into pellets, or, in a preferred embodiment, they may be separately fed to the feed hopper of an extruder. In a highly preferred embodiment, the glass fibers may be fed downstream in the extruder to minimize attrition of the glass. Generally, for preparing pellets of the composition set forth herein, the extruder is maintained at a temperature of approximately 480° F to 550° F. The pellets so prepared when cutting the extrudate may be one-fourth inch long or less. As stated previously, such pellets contain finely divided uniformly dispersed

glass fibers in the composition. The dispersed glass fibers are reduced in length as a result of the shearing action on the chopped glass strands in the extruder barrel.

Other Additives

5 The composition of the present invention may include additional components that do not interfere with the previously mentioned desirable properties but enhance other favorable properties such as antioxidants, colorant, including dyes and pigments, lubricants, mold release materials, nucleants or ultra violet (UV) stabilizers. Examples of lubricants are alkyl esters, for example pentaerythritol tetrastearate, alkyl amides, such as ethylene bis-stearamide, and polyolefins, such as polyethylene.

10 Also, the final composition may contain polytetrafluoroethylene (PTFE) type resins or copolymers used to reduce dripping in flame retardant thermoplastics.

In one embodiment, the thermoplastic polyester resin molding composition includes a core-shell impact modifier for enhancing heat resistance having a shell derived from an alkylacrylate and a rubbery acrylate core derived from an acrylate having 4 to 12 carbon atoms.

In another aspect of the invention a thermoplastic molding composition comprising the following is preferred;

- (a) 25-60% polycarbonate
- (b) 25-50% alkylene terephthalate
- 20 (c) 5-15% acrylic rubber core shell impact modifier
- (d) 5-20% organopolysiloxane-polycarbonate
- (e) 5-20 % flame retardant

The blends of the invention may be formed into shaped articles by a variety of common processes for shaping molten polymers such as injection molding,

compression molding, extrusion and gas assist injection molding. Examples of such articles include electrical connectors, enclosures for electrical equipment, automotive engine parts, lighting sockets and reflectors, electric motor parts, power distribution equipment, communication equipment and the like including devices that have
5 molded in snap fit connectors. The impact modified polyester resins can also be made into film and sheet.

Examples

The following examples illustrate the present invention, but are not meant to be limitations to the scope thereof. Examples of the invention are designated by
10 numbers, comparative examples are shown by letters. The examples of Table II and III were all prepared and tested in a similar manner:

The ingredients of the examples shown below in Table II and III, were tumble blended and then extruded on a 30 mm Werner Pfleiderer Twin Screw Extruder with a vacuum vented mixing screw, at a barrel and die head temperature between 240 and
15 265 degrees C and 300 rpm screw speed. The extrudate was cooled through a water bath prior to pelletizing. Test parts were injection molded on a van Dorn molding machine with a set temperature of approximately 240 to 265 °C. The pellets were dried for 3-4 hours at 120°C in a forced air circulating oven prior to injection molding.

20 Notched Izod (NI) testing as done on 3 x ½ x 1/8 inch bars using ASTM method D256. Bars were notched prior to test at various temperature.

Biaxial impact testing, sometimes referred to as instrumented impact testing, was done as per ASTM D3763 using a 4 x 1/8 inch molded discs. The total energy absorbed by the sample is reported as ft-lbs.

25 Accelerated weathering test was done as per ASTM-G26. The samples of 2 x 3 x 1/8 inch molded rectangular specimen, "color chip", were subjected to light in xenon arc weatherometer equipped with borosilicate inner and outer filters at an

irradiance of 0.35 W/m² at 340nm, using cycles of 90 min light and 30 min dark with water spray. The humidity and temperature were kept at 60% and 70°C, respectively.

Chip color was measured on a ACS CS-5 ChromoSensor in reflectance mode with a D65 illuminant source, a 10 degree observer, specular component included, CIE color scale as described in "Principles of Color Technology" F.W. Billmeyer and M. Saltzman/John Wiley & Sons, 1966. The instrument was calibrated immediately prior to sample analysis against a standard white tile. The color values reported below are the difference before and after UV exposure. The color change is expressed as delta E. Testing was done as per ASTM D2244.

The impact modifier used was a core-shell acrylic rubber. The impact modifier comprised a butyl acrylate (or derivatives thereof) core grafted to a poly(methyl methacrylate) shell. These pellets were obtained from Rohm and Haas under the trade name PARALOID® as PARALOID® 3330 or EXL3330. EXL3330 is a pelletized form of the powder acrylic rubber EXL3330. The acrylic modifier was made by an emulsion polymerization similar to that described in US Patent 3,808,180. It has an average particle size of about 600 nm.

The core-shell acrylic impact modifiers with polydimethylsiloxane and poly(butyl acrylate) in core was obtained from Mitsubishi Rayon Co. Ltd. under the trade name of Metablend S-2001.

The heat stabilizer was obtained from Ciba Geigy under the trade name IRGAPHOS® as IRGAPHOS® 168, which is a tris di-tert-butyl phenyl phosphite.

The heat stabilizer was obtained from Ciba Geigy under the trade name IRGANOX® as IRGANOX® 1010. This antioxidant is a tetra functional 2, 6-di-tert-butyl hindered phenol.

The heat stabilizer was obtained from Crompton Co under the trade name SEENOX® 412S, which is a tetra ester of pentaerythritol and 3-dodecylthiopropionic acid.

Table I shows the ingredients used in the blends discussed in the comparative examples (designated by letters) and the examples of the invention (designated by numbers).

5 All examples and comparative examples in Table II and III have 2% titanium dioxide, 0.1%-0.2% mono zinc phosphate, and less than 0.6 % of combined heat stabilizers of IRGANOX® 1010, IRGAPHOS® 168, and Seenox 412S

Examples A-C & 1

10 The composition of the blends and test results are shown in Table 2. Comparative examples A, B, and C show that a use of MBS induces good notched Izod impact on un-weathered samples. However, A, B, and C shows significant loss of impact properties after 1 month (720 hours) as per ASTM G26 accelerated weathering test. Comparative example C shows slightly better weatherability in terms of impact retention and color shift than B and C probably due to the 0.5 % UV absorber, UVA5411. However, more significant improvement in the weatherability was
15 achieved in the example 1. Example 1 shows that both good low temperature impact properties and weatherability can be obtained by using PC_ST and EXL3330. Note that the example 1 does not have UV absorber but still has much better weatherability than formulations with MBS.

Examples D – G & 2

20 Comparative examples F and G illustrate the enhanced weathering properties obtained by using EXL3330 only. However, EXL3330 only did not give good notched Izod impact at -10 °C and -20 °C. Comparative examples D and E shows that S-2001 induces slightly better initial notched Izod but causes earlier loss of instrumented impact under UV exposure than EXL3330. Example 2 demonstrates that the
25 combination of PC_ST and S-2001 improves notched Izod impact as well as weatherability of the blend. Note that comparative examples D-G and example 1-2

have lower color shift than comparative examples A-C with MBS after G26 weathering

Table I

Abbreviation	Materials
MBS	Butadiene-styrene-methyl-methacrylate core-shell rubber impact modifier, EXL3691 from Rohm and Haas Company
Lotader	Lotader ® modifier AX8900 from Elf Atochem contains 67% of ethylene, 25% of methyl acrylate, and 8% of glycidyl methacrylate
S-2001	Core-shell type impact modifier with silicone-acrylic-based rubber, METABLEN S-2001 from Mitsubishi Rayon.
EXL 3330	Acrylic impact modifier from Rohm and Haas
PC_ST	SiloxanePC Eugenolcapped siloxanecopolycarbonate, 20 % polydimethylsiloxane by wt %
UVA5411	2-(2'HYDROXY-5-T-OCTYLPHENYL)-BENZOTRIAZOLE, UV stabilizer
Tinuvin 234	Benzotriazol UV stabilizer from Ciba-Geigy Company
PC	PC bisphenol polycarbonate Lexan ® resin from General Electric Company
PBT 315	Poly(1,4-butylene terephthalate) Mw ~37,000 from GE Plastics
Sb ₂ O ₃	Antimony trioxide
LDPE	Low density polyethylene
BC52	Phenoxy-terminated tetrabromobisphenol-A carbonate oligomer, flame retardant from Great Lakes Chemical Co.
ML1624	Brominated flame-retardant PC from GE plastics.
Br-acrylate	Poly(pentabromobenzyl acrylate) MW 15,000, 71% Bromine
PTFE	Poly(tetrafluoroethylene), anti-dripping agent

Table II

	Comparative Example A	Comparative Example B	Comparative Example C	Example 1
MBS	8.0	9.0	10.0	-
Lotader	2.0	-	-	-
S-2001	-	-	-	-
EXL3330	-	-	-	12
PC_ST	-	-	-	15
UVA5411	0.25	-	0.5	-
Tinuvin234				
PC	37.3	30.0	34.0	28.3
PBT	38.0	38.0	35.0	34.0
Br-acrylate	10.9			
ML1624		20.0	15.4	
BC52				8.1
Sb2O3	3.5	3.0	3.1	2.4
LDPE			2.0	
PTFE	0.07	-	-	0.2
Initial notched Izod impact (ft-lb/in)				
at 0 degree C	14.5 (100%)	13.9 (100%)	13.3(100%)	15.1 (100%)
at 0 degree C	-	12.1 (100%)	11.6(100%)	14.0 (100%)
at -10 degree C	12.0 (100%)	11.7 (100%)	11.2(100%)	12.3 (100%)
at -20 degree C	12.0 (20%)	9.6 (80%)	10.4(100%)	11.5 (100%)
Instrumented impact at -20 degree C after ASTM G26 weathering (ft-lb)				
0 hrs, G26	25.2 (100%)	26.4 (100%)	26.8(100%)	28.2 (100%)
720 hrs, G26	1.3 (0%)	2.1 (0%)	6.5 (0%)	23.4 (100%)
1440 hrs, G26	1.2 (0%)	2.2 (0%)	-	17.8 (100%)
Notched Izod impact at RT after ASTM G26 weathering (ft-lb/in)				
0 hrs, G26	12.9	11.1	-	15.2
720 hrs, G26	11.5	8.6	-	14.4
1440 hrs, G26	10.6	8.1	-	13.6
2880 hrs, G26	5.4	5.5	-	13.1
Color shift (delta E) after ASTM G26 weathering				
720 hrs, G26	11.4	8.1	5.9	5.0
1440 hrs, G26	13.7	9.8	-	4.3

Table III

	Comparative Example D	Comparative Example E	Comparative Example F	Comparative Example G	Comparative Example 2
MBS	-	-	-	-	-
Lotader	-	-	-	-	-
S2001	8	12	-	-	9.2
EXL3330	-	-	8	12	-
PC ST	-	-	-	-	10.6
UVA5411	0.25		0.25	0.5	0.5
Tinuvin234		0.5			
PC	41.3	36.6	42.4	36.7	32.8
PBT	37.0	38.0	37.0	37.0	35.8
BC52	10.0	9.6	9.0	10.3	8.0
Sb2O3	3.1	2.9	2.7	3.1	2.9
LDPE					
PTFE	0.4	0.4	0.6	0.4	0.2
Initial notched Izod impact (ft-lb/in)					
at 0 degree C	15.5(100%)	15.5(100%)	16.3(100%)	16.6(100%)	15.0 (100%)
at 0 degree C	11.2(80%)	13.2(100%)	6.2(20%)	13.8(100%)	13.7 (100%)
at -10 degree C	5.0(0%)	8.1(60%)	4.0(0%)	4.7(0%)	12.8 (100%)
at -20 degree C	4.1(0%)	4.5(0%)	3.6(0%)	4.0(0%)	6.9 (20%)
Instrumented impact at -20 degree C after ASTM G26 weathering (ft-lb)					
0 hrs, G26	31.9(100%)	33.4 (100%)	31.8(100%)	30.1(100%)	32.2 (100%)
720 hrs, G26	30.4(100%)	29.2 (100%)	32.5(100%)	25.7(100%)	28.0 (100%)
1440 hrs, G26	1.6(0%)	0.9 (0%)	15 (50%)	29.9(100%)	26.6 (100%)
Notched Izod impact at RT after ASTM G26 weathering (ft-lb/in)					
0 hrs, G26	15.5	15.5	16.2	16.6	15.1
720 hrs, G26		14.7			14.6
1440 hrs, G26	14.3	14.0	14.1	14.5	14.2
2160 hrs, G26		13.6			14.1
2880 hrs, G26	13.5		13.3	14.0	-
Color shift (delta E) after ASTM G26 weathering					
720 hrs, G26	4.4	4.6	4.3	4.3	4.7
1440 hrs, G26	3.5	4.2	3.9	3.9	3.8